

AMENDMENT (2003)

Page 3

Further, it should be noted that the bulletin TDS-182 on page 2, footnote, generally identifies Pemulen as being described by "Carbomer 1342" monograph earlier submitted by the Applicants.

The Applicants submit that the amendment to the specification and the submittal of the hereinabove noted bulletin overcomes the Examiner's objection to the specification under 35 U.S.C. 112, first paragraph.

In addition, claims 22 and 23 have been amended to incorporate the element polysorbate 80 and to correct for the misspelling of "glycerine".

The Applicants submit that this amendment to the claims overcomes the Examiner's rejection of claims 22 and 23 under 35 U.S.C. 112, first paragraph.

Further, claims 1-4, 9, 22-24 have been rejected by the Examiner under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicants regard as the invention.

In response thereto, the Applicants have now amended the specification to define the term "Pemulen" and have submitted prior art publications showing that the trademark "Pemulen" has the definition inserted into the specification.

AMENDMENT (2003)

Page 4

In view of the fact that claims 5-8 have been canceled by the present amendment and the Examiner's indication that claims 1-4, 9 and 22-24 would be allowable if rewritten or amended to overcome the rejection under 35 U.S.C. 112, the Applicants submit that the application is now in condition for allowance and such action is respectfully requested.

Respectfully submitted,



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Jan 6, 1995
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Introducing the New, Universal **PEMULEN®** POLYMERIC EMULSIFIERS

TDS-182
Revised 3/93

Pemulen® polymeric emulsifiers are predominantly high molecular weight polyacrylic acid polymers. These novel primary emulsifiers have a small oil-loving (lipophilic) portion in addition to a large, water-loving (hydrophilic) portion.

This chemical structure allows these copolymers to function as primary emulsifiers in oil-in-water pharmaceutical emulsions. Whereas Carbopol® water soluble polymers have proven useful as secondary oil-in-water (o/w) emulsion stabilizers, Pemulen polymers can actually form o/w emulsions. The lipophilic portion adsorbs at the oil-water interface, and the hydrophilic portion swells in the water forming a gel network around oil droplets to provide exceptional emulsion stability to a broad range of oils.

How Pemulen Polymeric Emulsifiers Work

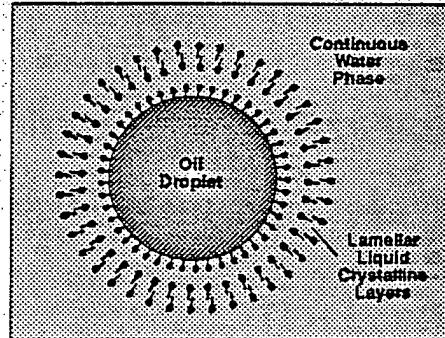
Traditionally, ionic or non-ionic surfactants stabilize oil-in-water emulsions principally by adsorbing and forming lamellar liquid crystalline layers at the emulsion interface, requiring usage levels of 3-7%. The hydrophilic-lipophilic balance (HLB) of the oil and surfactant phases must be carefully matched to insure good emulsion stability. Often polymeric hydrocolloids, such as Carbopol resins, are added to increase the stability of the oil-in-water emulsions by thickening and adding yield value or structure to the water phase.

Emulsions created with very low levels of Pemulen emulsifiers are highly stable. Oil droplets are protected and held in place as a result of the very high yield aqueous gel around each oil droplet. On forming o/w emulsions, Pemulen molecules form an adsorbed gel layer around each oil droplet, with the hydrophobic portions of the polymer anchored in the oil phase. Thus, when two oil droplets approach each other, a physical repulsive force is generated by the presence of these adsorbed gel layers. This mechanism is represented in Figure 1.

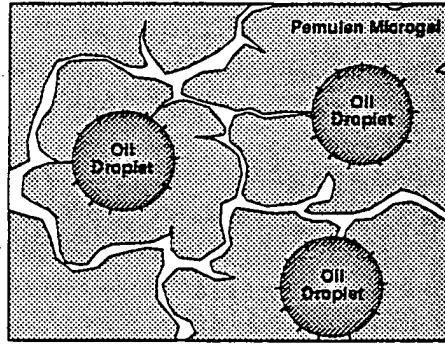
Benefits of Pemulen Polymeric Emulsifiers

- Universal Emulsifier of Any Oil Into an O/W Emulsion
- Excellent Emulsion Stability
- High Efficiency/Low Usage Levels
- Low Irritancy
- Rapid Release of the Oil Phase Upon Emulsion Application
- Simplifies Emulsion Formulation Procedures
- Effective Emulsions at Low Oil Phase Loadings
- Reduction of Application Frequency
- Enables Unusual New Product Forms

Figure 1



Traditional Surfactant-Stabilized Emulsion



Emulsion Stabilized with Pemulen Polymeric Emulsifiers

BFGoodrich

The BFGoodrich Company · Specialty Polymers & Chemicals Division · 9911 Brecksville Road, Cleveland, Ohio 44141-3247 · 800-331-1144

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Benefits of Pemulen® Polymeric Emulsifiers

Pemulen polymeric emulsifiers¹ are novel oil-in-water (o/w) emulsifiers which provide numerous benefits to emulsions prepared with them:

Universal Emulsification—Pemulen emulsifiers are water soluble polymers that readily anchor at the oil-water interface independent of oil type. Pemulen emulsifiers do not depend on building liquid crystalline structures to provide emulsion stability, therefore, they can be used with virtually any oil phase, regardless of the oil phase HLB or temperature of emulsification. Oil-in-water emulsions have been made with many non-reactive, non-ionic oil types, including mineral oil, volatile silicone oils, aromatic oils, fatty ethers or esters, and hydrocarbons/waxes. Oils can be emulsified at room temperature, and fats or waxes are emulsified at their molten temperature.

The following is a sample of products that have been successfully emulsified in water with 0.4% or less Pemulen TR-2NF:

- Cyclomethicone
- Perfluorinated Oils
- Linseed Oil
- Coal Tar
- Mineral Oil
- Silicone Fluid
- Mink Oil
- Tallow
- Napthenic Oil
- Tung Oil
- Oleic Acid

Excellent Stability—A broad range of emulsions have remained stable in the bottle for years, even at elevated temperatures of 40°C. (See Figure 2) These emulsions are also stable to repeated freeze-thaw conditions.

Low Irritancy/Low Usage Levels—Due to their hydrogel nature and highly efficient properties, typical usage levels of only 0.1-0.3% of a Pemulen emulsifier are required to replace 3-7% of traditional and potentially skin-irritating surface active emulsifiers.

Oil Phase Will Not Re-Emulsify—When formulated with little or no surfactant, the oil phase in a Pemulen emulsion can spread rapidly and cannot re-wet. Waterproof emulsions are therefore easily prepared. In traditional emulsions, upon final evaporation of the water phase, the oil layer contains high concentrations of surfactants,² rendering the oil phase readily re-emulsifiable.

¹ CTFA name: Acrylates/C10-30 Alkyl Acrylate Cross-Polymer. Products can be generically described by the "Carbomer 1342" monograph in the USP XXII/NF XVII, however, Pemulen resins provide additional emulsification functionality. Pemulen resins are polymerized in a patented ethyl acetate-cyclohexane mixture. This solvent mixture is environmentally and toxicologically preferred to benzene and chlorinated solvents.

Figure 2

Median Droplet Sizes of Emulsion Gels Prepared by Different Methods in Relation to Storage Time

At room temperature:

	Median Droplet Size (μm)	after preparation	after 1 month	after 3 months	after 6 months
Manual process	300 (100-1000)	250 (100-1000)	300 (100-1000)	300 (100-1000)	300 (100-1000)
Mechanical process	20 (10-30)	25 (10-40)	25 (10-40)	25 (10-40)	25 (10-40)

At elevated temperature (40°C.):

	Median Droplet Size (μm)	after preparation	after 1 month	after 3 months	after 6 months
Manual process	300 (100-1000)	300 (100-1000)	300 (100-1000)	300 (100-1000)	300 (100-1000)
Mechanical process	25 (10-40)	25 (10-40)	25 (10-40)	25 (10-40)	25 (10-40)

Source: Bremicker, Klaus et al: In *Die Pharmazeutische Industrie* 54;182-185; (1992)

Rapid Release of the Oil Phase—Emulsions created with Pemulen emulsifiers have a triggered release mechanism. The acrylic hydrophilic portion of the Pemulen emulsifier hydrogel de-swells upon contact with the surface characteristics and salt content common on skin to release the oil phase and provide immediate coverage of the oil phase, eliminating the lengthy lag time seen in traditional o/w emulsions.

In traditional emulsions, lamellar liquid crystals, comprised of oil, water, and surfactant, retard the rate of deposition of the oil phase to the substrate.² These liquid crystal structures persist for up to ninety minutes after application. The liquid crystal structures may be observed by polarized light microscopy. The time lag from application to the formation of the continuous oil phase is caused by the slow evaporation of the water phase from the liquid crystal structures.

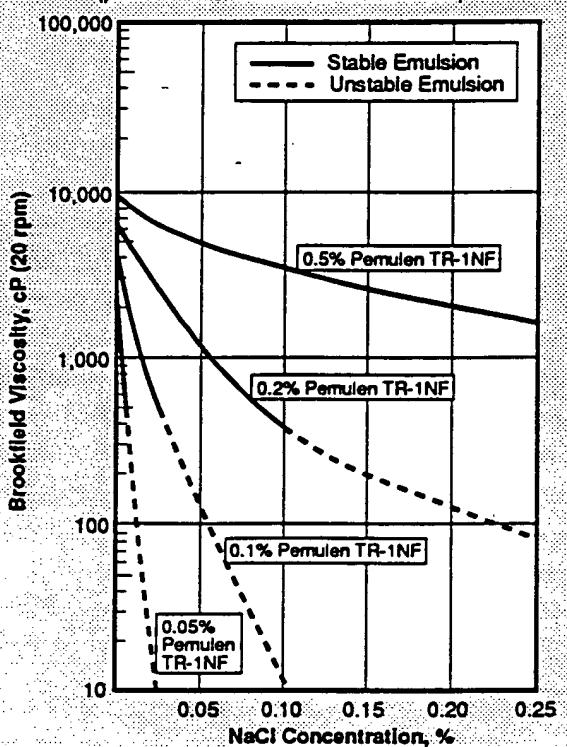
Simplifies Emulsion Formation Procedures—Stable emulsions can be formed by the stepwise addition of oil phase ingredients to the water phase at any temperature, including ambient room temperature, at which point all ingredients are liquid. Economies may be derived from the elimination of heating and cooling cycles during manufacture.

² H. Tsutsumi, T. Utsugi and S. Hayashi, *Journal of the Society of Cosmetic Chemistry*, 30, 345, 1979

Figure 3

Effect of NaCl Concentration on Emulsion Viscosity and Stability for Pemulen TR-1NF and 5.0% Mineral Oil¹ O/W Emulsion

(pH = 7.0 ± 0.2, neutralized with 18% NaOH)

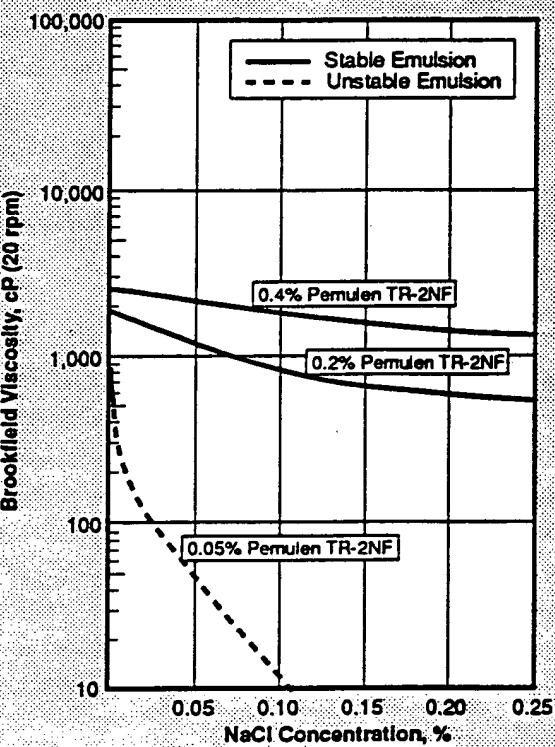


¹ Drakeol 21 (Penreco)

Figure 4

Effect of NaCl Concentration on Emulsion Viscosity and Stability for Pemulen TR-2NF and 5.0% Mineral Oil¹ O/W Emulsion

(pH = 7.0 ± 0.2, neutralized with 18% NaOH)

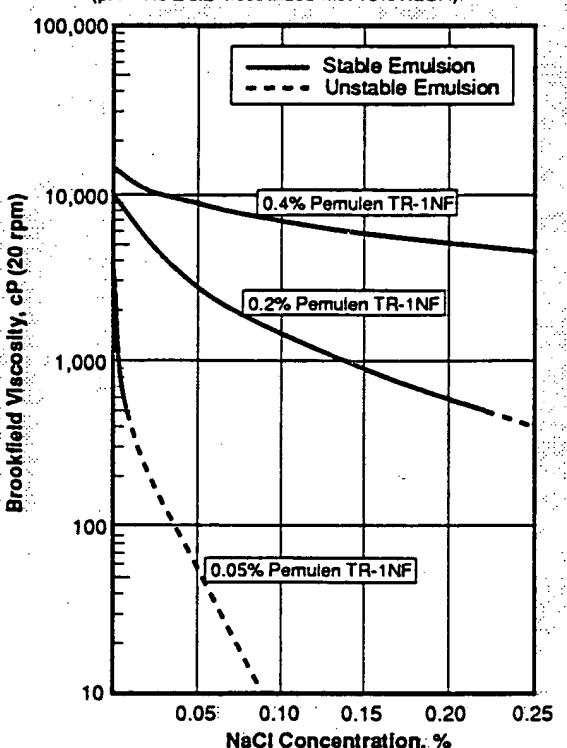


¹ Drakeol 21 (Penreco)

Figure 5

Effect of NaCl Concentration on Emulsion Viscosity and Stability for Pemulen TR-1NF and 30.0% Mineral Oil¹ O/W Emulsion

(pH = 7.0 ± 0.2, neutralized with 18% NaOH)

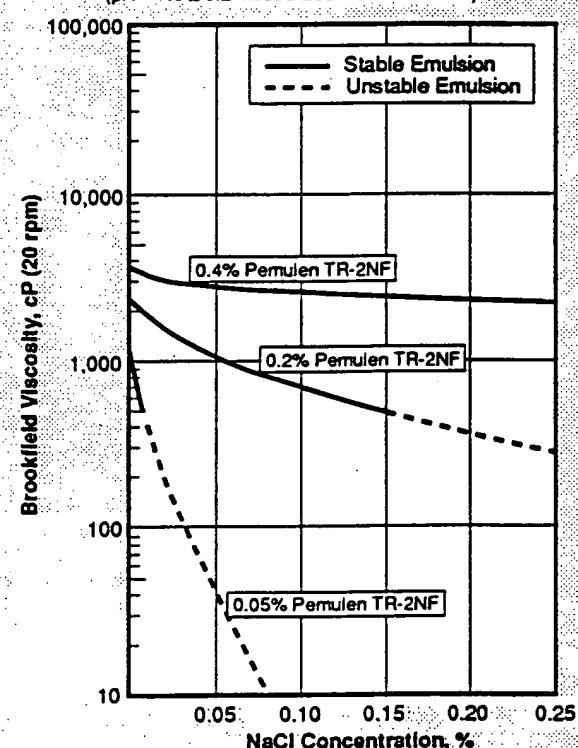


¹ Drakeol 21 (Penreco)

Figure 6

Effect of NaCl Concentration on Emulsion Viscosity and Stability for Pemulen TR-2NF and 30.0% Mineral Oil¹ O/W Emulsion

(pH = 7.0 ± 0.2, neutralized with 18% NaOH)



¹ Drakeol 21 (Penreco)

Formulation Guidelines

Compatibility—Pemulen® polymeric emulsifiers are compatible with a broad range of nonionic or slightly ionic water soluble materials. High levels of electrolytes will prevent the normal swelling of the hydrophilic portion of the molecules, and emulsion creaming may result. (See Figures 3-6) Cationic species often complex with Pemulen resins, although low levels of many cationic materials are compatible and effective as spreading and wetting agents. (See TDS-124 for more details.)

Particle Size—Pemulen resins are capable of producing extremely stable macro emulsions, even at large average oil particle sizes (approaching 1-2 millimeters diameter). For aesthetic reasons it is often desirable to produce small particle size (1-5 micron) emulsions having a high degree of whiteness, opacity and creamy appearance. Low levels (0.1-0.4%) of liquid medium HLB (8-12) nonionic surfactants such as a nonyl phenoxy-poly (ethyleneoxy) ethanol (Igepal CO-530, Rhône-Poulenc) or sorbitan monooleate (Span 80, ICI) are very effective additives

for achieving these particle sizes. High shear mixing may reduce particle size. In-line non-recycling homogenizers and colloid mills should be used *in controlled moderation* to avoid degradation of the polymer's hydrophilic gel network which would contribute to emulsion instability.

Emulsion Formation for Standard Aqueous Solutions

- Neutralization—Pemulen resins are mildly acidic polymers and function best when neutralized with a suitable water soluble base to the optimum pH. The optimum pH is a function of oil loading: the lower the oil loading, the broader the acceptable pH range. (See Figure 7) Inorganic alkali bases such as sodium hydroxide, potassium hydroxide or ammonium hydroxide are effective neutralizing agents. In addition, organic amine bases such as triethanolamine, tromethamine, aminomethyl propanol and tetrahydroxypropyl ethylenediamine are particularly suitable due to their relative mildness and lower usage levels required. (See Table 1) Amino acids such as β -alanine and lisine can also be used for neutralization and viscosity modification

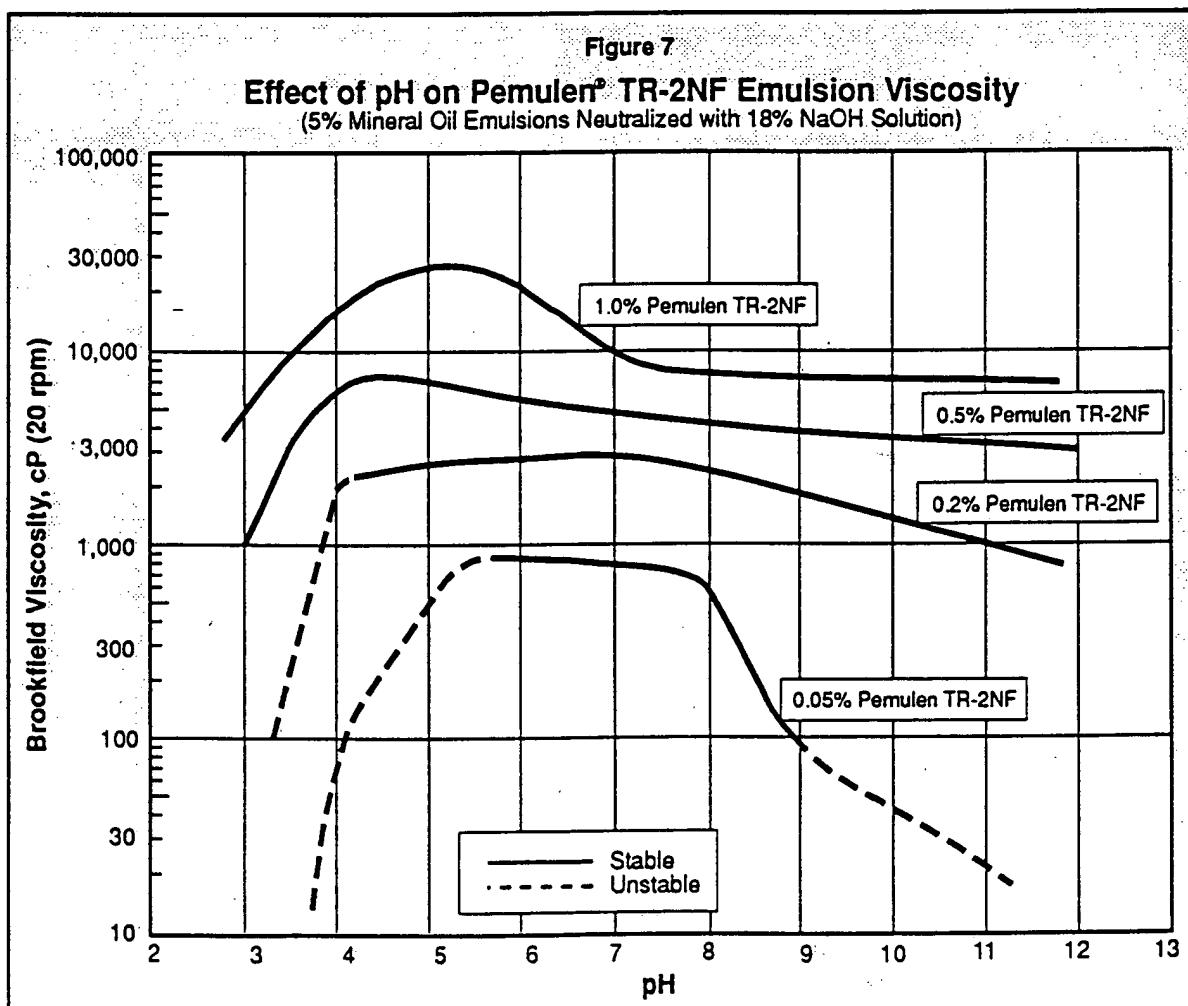


Table 1
**Relative Ratio of Base to One Part
 Pemulen® by Weight**
 (Neutralized to an approximate pH of 6.0-7.0)

Sodium hydroxide (18% solution)	0.5
Potassium hydroxide (18% solution)	0.5
Ammonium hydroxide (28% solution)	0.3
Triethanolamine (TEA)	2.0
Tromethamine (2-Amino 2-Hydroxymethyl-1, 3-propanediol)	2.0
Aminomethyl propanol (AMP)	1.5
Tetrahydroxypropyl ethylene diamine	2.0

Emulsion Formation for Low-pH Systems - Hydrogen Bonding—In cases where forming a stable emulsion by increasing the pH is inappropriate, hydrated molecules of Pemulen resin can also be uncoiled in water systems by adding 10-20% of a hydroxyl donor. Some commonly used hydroxyl donors are: polyols (such as glycerine, propylene glycol and polyethylene glycol), sugar alcohols (such as mannitol), nonionic surfactants with five or more ethoxy groups, glycol-silane copolymers, polyethylene oxide, and fully hydrolyzed polyvinyl alcohol, among others.

These reagents hydrogen-bond with the Pemulen resin molecule causing it to uncoil. The hydrogen bonding is not instantaneous — maximum thickening may take from five minutes to three hours. Heating the dispersion hastens thickening, but temperatures above 60°C (140°F) should not be used. (Figure 6)

Stable emulsions may be formed with Pemulen resins without neutralization when the system contains 10% or more polyethoxy or polyhydroxy liquid. By employing the procedure on this page (See box) and using the following ingredients, it may be possible to produce a good starting point aqueous phase:

Ingredient	% by Weight
Polyethylene glycol	
hydroxyl donor	10.00
Water	89.00
Pemulen TR-1 or TR-2 resin	1.00
	100.00

Hydrogen Bonding Thickening Procedure for Aqueous Systems

1. Disperse the active ingredient into the phase in which it is most soluble.
2. Combine the hydroxyl donor and the water phase.
3. While rapidly agitating (800 - 1500 rpm), sift the Pemulen resin into this blend slowly to avoid lumping.
4. Continue stirring until viscosity begins to build. Heating to 60°C (140°F) usually hastens this process.
5. Add the oil phase under rapid agitation (800 - 1500 rpm). Continue mixing to reduce particle size and to obtain a glossy product.

NOTE: Nonionic surfactants containing 5 or more moles of ethylene oxide can be used at lower concentrations. If an eductor is used, add the surfactant to the water phase before adding the Pemulen resin.

Moderation of Breaking Upon Application—Emulsions prepared using Pemulen resins as the sole emulsifier or thickener release the oil phase very quickly upon application. This effect may not be desirable in some applications. To decrease the rate of emulsion breaking when applied, the use of a low level of a slightly surface active film former is recommended. Hydroxypropyl methylcellulose at a 0.10% concentration, or Poloxamer 181, 182 or 183 at 0.5% concentration are very effective. Formulations which contain some surfactant resulting in a relatively small particle size and higher phase volume of oil (e.g. >30%) may not require such an additive.

Structuring/Body Agents—Use of compounds that typically structure o/w emulsions at the interface, such as cetyl and stearyl alcohols and partial glycerides should be limited. Undesirable, highly cohesive textures often result, and the lyotropic liquid crystals formed by cetearyl alcohols will delay the release of the oil phase for emollient properties or protection behavior.

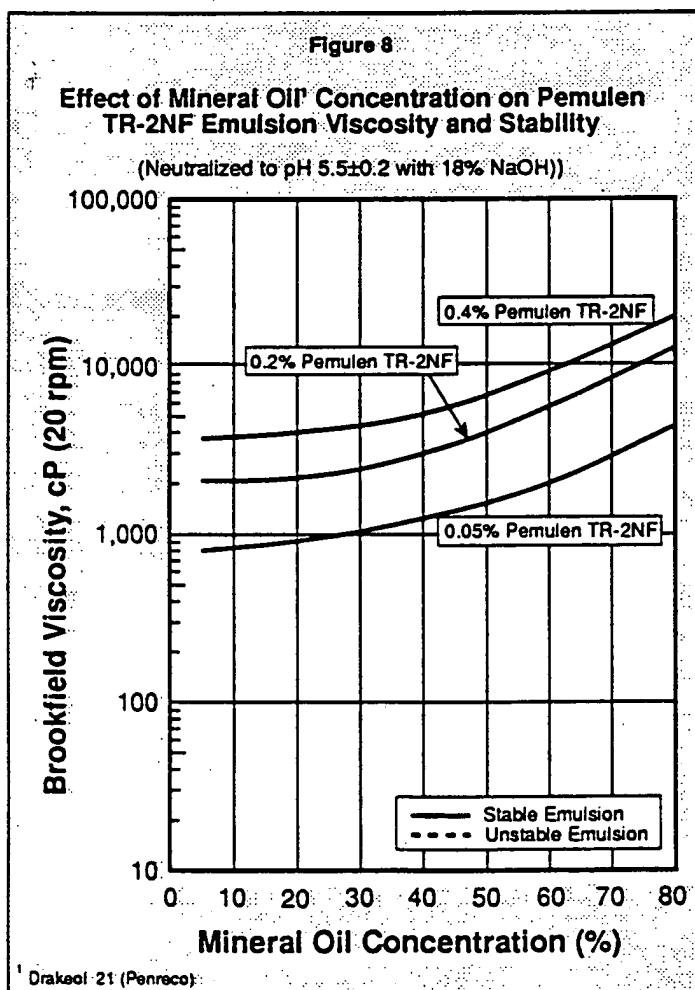
Thickening—Pemulen polymeric emulsifiers do provide some thickening of o/w emulsion formulations. If additional body or thickening is desired, Carbopol resins are

recommended, typically at 0.2-0.6% concentrations.

Emulsification Procedure

Pemulen® emulsifiers are adaptable to a variety of emulsion preparation methods. Pemulen powder is most easily dispersed in room temperature oil. The oil phase is combined with the water phase containing the neutralizing alkali or amine using rapid, turbulent mixing action.

In the presence of some polar oils (aromatic or dicarboxylic acid esters) or molten oils above 60°C, Pemulen may physically plasticize, hindering stable emulsion formation. Dispersing Pemulen directly into the water in these cases will result in smooth, stable emulsions.



Drakeol 21 (Penreco)

Indirect Method

1. Disperse the active ingredient into the phase in which it is most soluble.
2. Disperse the Pemulen polymeric emulsifier in the oil phase until the powder is wetted in the oil.
3. Under rapid agitation (800 - 1500 rpm), add the neutralizing agent.
4. Add the oil phase (containing Pemulen) to the water phase, containing the neutralizing alkali, under vigorous (800-1500 rpm) agitation. Do not use in-tank homogenizers.
5. Pemulen will swell rapidly in the water phase causing a swift build of viscosity and the formation of a creamy emulsion. Continue with vigorous agitation for 15-20 minutes.

Direct Addition Method

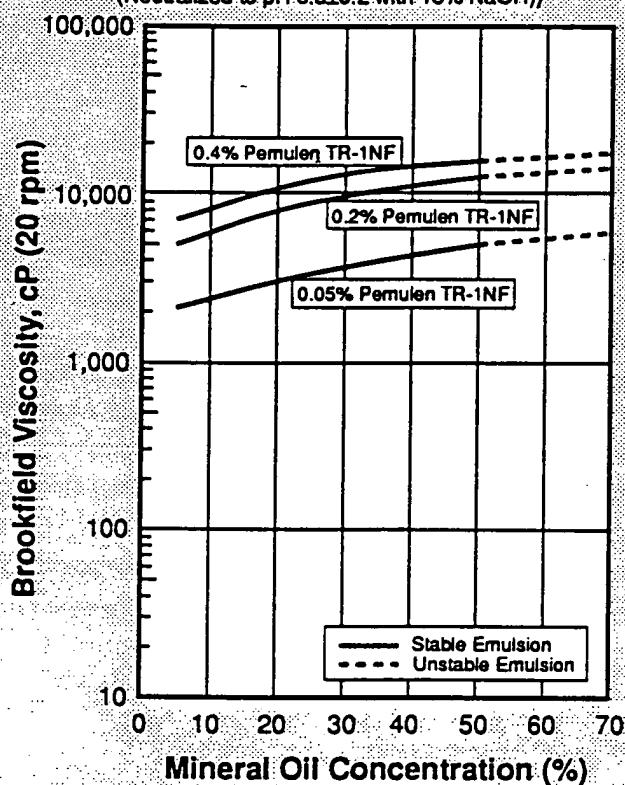
1. Disperse the active ingredient into the phase in which it is most soluble.
2. Disperse the Pemulen polymeric emulsifier by sifting slowly into the rapidly agitating water phase. An eductor or powder disperser may be used to speed dispersion. Foaming will occur during this step.
3. Continue agitation, pour in the oil phase, and neutralize with a suitable base.
4. Use rapid (800-1200 rpm) mixing to reduce particle size and obtain a glossy product. Controlled homogenization may be useful, but viscosity variation could result from high shear.

NOTE: Liquid nonionic surfactant (HLB 8-12) in a concentration of 0.1-0.4% may be added to the oil phase to reduce the size of the oil droplets, and improve the creamy appearance of the emulsion.

Figure 9

Effect of Mineral Oil¹ Concentration on Pemulen TR-1NF Emulsion Viscosity and Stability

(Neutralized to pH 5.5±0.2 with 18% NaOH))



¹ Drakol 21 (Penreco)

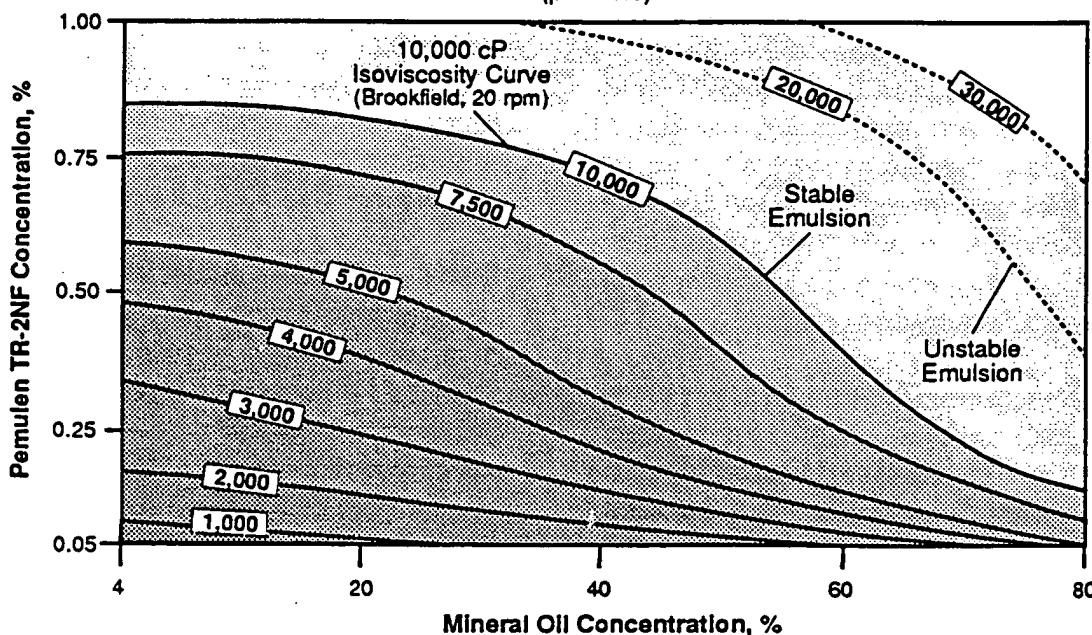
Pemulen[®] Type Selection

In general, the selection of Pemulen type is based upon the level of oil to be emulsified:

Pemulen TR-1NF is a versatile polymeric emulsifier which can easily emulsify up to 30% oil by weight, within a pH range of 4-5.5, and up to 20% oil over the pH range of 3-11. (See Figure 9) While Pemulen TR-1NF thickens the water, Carbopol resins should be used with Pemulen TR-1NF to provide greater thickening properties where higher viscosity emulsions are required.

Pemulen TR-2NF can emulsify the highest levels of oil (up to 60-80% by weight) within a pH range of 4-8. (See Figures 7, 8 and 10) Pemulen TR-2NF is highly effective at levels below 0.4% where the mode of emulsion application is via spray mechanism.

Figure 10
Viscosity Phase Diagram for Oil/Water Emulsion
(pH = 5.5)



Testing for a Stable Emulsion

After you have made an emulsion, there are a number of different ways to test if it will remain stable over time. Here are the most common:

1. **Viscosity vs. Time**—After the emulsion is made, measure the original viscosity and periodically thereafter to detect any large changes. If a 10% deviation from the original viscosity results in less than 3 months at room temperature, this is a sign of an unstable emulsion.
2. **Centrifuge**—Subjecting the emulsion to a 5-10 g force for several minutes will test the resistance to creaming. Although this test exerts an artificially elevated gravitational force on the emulsions, it can determine the yield strength of the emulsion that assists in maintaining stability to phase separation.
3. **Emulsion Droplet Size Analysis**—Image (microscope) or other analytical size analysis may detect a broad droplet size distribution in Pemulen o/w emulsions. Unlike conventional emulsions, *this is not a predictor of emulsion instability*.
4. **Heat Storage Test**—Viscosity rise of less than 20% over original values after storage of samples at 50°C for one month indicates room temperature stability for one year. A viscosity rise is the precursor to visible creaming. Be sure there is as little head space as possible, as the water in the emulsion may evaporate and re-condense, forming a liquid layer that may be mistakenly identified as a broken emulsion.

Emulsion Troubleshooting Guide

If you are having problems creating a stable emulsion, the following factors play a role in emulsion stability:

1. **pH**—The optimum pH for an emulsion using Pemulen® TR-2NF is 4-8. A pH above or below this range may cause an unstable emulsion.
2. **High Shear Mixing or Pumping**—Pemulen polymeric emulsifiers form a gel matrix adsorbing on the oil droplet that physically stabilizes the emulsion. High shear mixing, with colloid mills, homogenizers, etc., or high shear pumping can break down the Pemulen polymer structure resulting in viscosity loss and potentially causing emulsion creaming. If homogenization is necessary, control emulsion exposure by using an in-line homogenizer. Use low shear pumps, such as reciprocating diaphragm or auger/gear pumps.
3. **Salt or Soluble Cations**—Pemulen polymers are sensitive to salts and cations, and use of products with greater than 0.1% of strongly ionizable salts should be minimized if possible. Use deionized water. Add salts after emulsion has been formed to determine their impact. Multivalent ions (Ca⁺, Mg²⁺, Fe³⁺, Al³⁺, etc.) have the most serious effects and should be rigorously excluded.
4. **Particle Size**—Although Pemulen can produce stable emulsions with oil droplets as large as 0.5 mm in diameter, too large an oil droplet may at times make suspension of the oil droplet in water more difficult. The particle size of the oil droplet can be decreased by increasing the mixing time, *using moderate shear agitation* when the emulsion is made, or by the use of a liquid nonionic surfactant (HLB 8-12) at 0.1-0.4 wt. %.
5. **Pemulen Level**—Modest amounts of Pemulen are used to emulsify the oil. As described earlier in this bulletin, *more Pemulen is not necessarily better*. As the amount of oil increases, the amount of Pemulen required to successfully emulsify it tends to be reduced. (See Figure 10)
6. **Emulsification Method Used**—If the indirect method caused an unstable emulsion, try the direct method.

For further assistance, please call our customer service department toll-free on 1-800-331-1144.

Summary

Pemulen® resins are universal oil-in-water emulsifiers which can provide a wide range of stable and effective pharmaceutical emulsion forms. Traditional products can be made with unsurpassed stability, low irritancy, and improved performance, while the possibilities for novel emulsions are limited only by the imagination.

Please contact BFGoodrich toll-free at 800-331-1144 to discuss the product possibilities with Pemulen polymeric emulsifiers. We will be happy to provide samples, formulation assistance, pricing and other information.

For more details on specific applications for Pemulen use, please consult:

TDS-115	Waterproof Sun Screen Products
TDS-117	Skin Care Products
TDS-118	Fragrance Products
TDS-124	Cationic Skin Lotions.